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VEHICLE-SCALE TESTING SERVICE
OF THE
NATIONAL BUREAU OF STANDARDS
CONDUCTED IN COOPERATION WITH THE STATES
NOVEMBER, 1936 - MAY, 1938

Page

Introduction - 1
Statistical Data on Tests and Inspections - - - 3
Newly-Installed Motor-Truck Scales - - - - - - - - 14
Method of Test and Inspection of Vehicle Scales Developed by the Bureau - - - - - - - - - - - - 22
Requirements for Corner Tests of Vehicle Scales- 28
Statement of Vehicle-Scale Tolerances, and Related Specification Paragraphs - - - - - - 38

INTRODUCTION

The National Bureau of Standards inaugurated its program of vehicle-scale testing in cooperation with State and local weights and measures officials in November 1936. For somewhat detailed accounts of the purposes of this program, of the Bureau's testing unit, and of the general plans under which the work is carried on, reference may be made to the Reports of the Twenty-Sixth and Twenty-Seventh National Conferences on Weights and Measures.

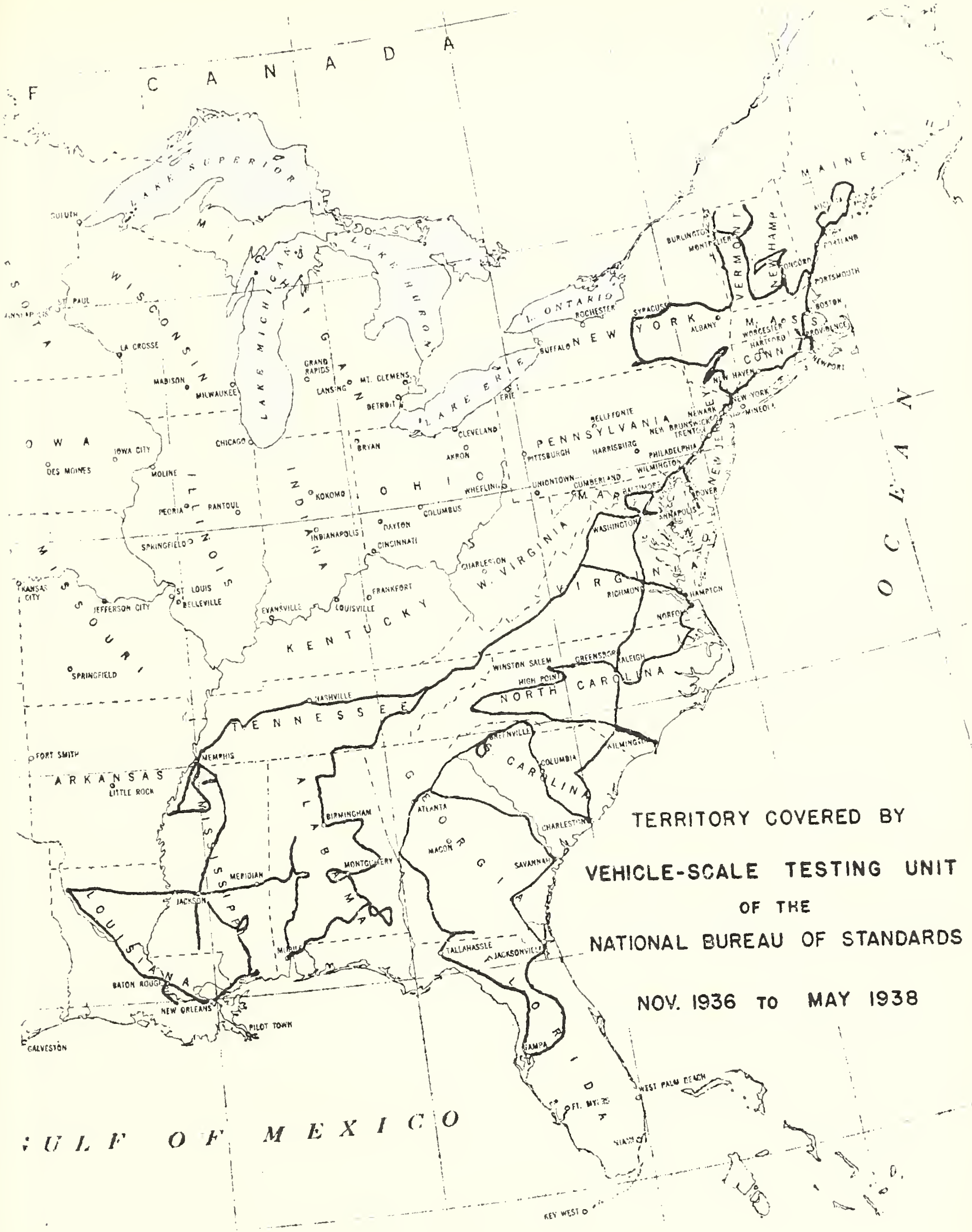
A year ago there was presented to the National Conference a report upon the results of the Bureau's tests of vehicle scales, covering the period from the beginning of the work to May 19, 1937. During that period, cooperative testing schedules had been completed in five States, Virginia, North Carolina, South Carolina, Georgia, and Florida.

With this present report on the vehicle-scale testing service of the Bureau, it is proposed to inaugurate a series of reports, to be issued in succeeding years, each of which will summarize results in this field from the beginning of the service, and will include such analysis, comments, and recommendations as may be considered timely and appropriate. It is believed that this plan will provide more informative data than separate reports on each year's work, because the work will continually be prosecuted in new territory and hence the results of one year's testing will never be directly comparable with the results of another year's work, as would be the case were the same territory being covered year after year. The present report, therefore, is concerned with a study of the results of the Bureau's tests of vehicle scales for the period November, 1936 - May, 1938, and related matters.

Testing schedules have been completed in sixteen States, Virginia, North Carolina, South Carolina, Georgia, Florida, Maryland, Delaware, Rhode Island, Maine, New Hampshire, Vermont, New York, Alabama, Mississippi, Louisiana, and Tennessee. The cooperating officials have been officers exercising full or limited weights and measures powers in all but two of the States enumerated; in Mississippi and in Louisiana the Governors designated the State Department of Agriculture and the Department of State Police, respectively, as the cooperating agencies.

Some few State-owned scales were tested in Connecticut and New Jersey, and a few Federal scales were tested in Massachusetts and Pennsylvania; no commercially-owned scales were tested in these four States, since the States were already, or were about to be, equipped with adequate testing equipment of their own, and no work by the Bureau's unit was needed.

The route followed by the Bureau's equipment is shown on the map on the following page.



TERRITORY COVERED BY
VEHICLE-SCALE TESTING UNIT
OF THE
NATIONAL BUREAU OF STANDARDS
NOV. 1936 TO MAY 1938

STATISTICAL DATA ON TESTS AND INSPECTION

There have now been made well over 1000 tests of vehicle scales. Of this number, 46 tests have been of scales owned by the Federal Government. Arrangements are made to test, with the Bureau's equipment, Federally-owned vehicle scales located in the territory traversed; since, however, such tests are not included in the State schedules and the scales are not subject to supervision by weights and measures officials, data on these tests are not included in this report.

It should be stated that a very few scales have been tested twice, and that for statistical purposes each such retest has been treated as though made on a scale not previously tested.

This report, then, is concerned with a study of the results of tests made by the Bureau on scales owned by States, cities, towns, counties, and commercial agencies. The number of tests involved is 967. Of these 967 scales, 433 scales, or 45 percent, were of the wagon type, and 534 scales, or 55 percent, were of the motor-truck type; 205 scales, or 21 percent, were equipped with dials or with automatic-indicating devices having a substantial weighing range; 27 scales, or 3 percent, were equipped with over-and-under indicators carrying weight graduations; and the total of the two groups having automatic indication of weight of whatever extent comprised 232 scales, or 24 percent of those tested.

Accuracy. Statistical data are presented in the table which follows, scales being separated first upon the basis of their type, and second upon the basis of ownership or principal use. The mean percentage errors are computed from maximum percentage errors developed in the tests, regardless of the size or position of the test-weight load. Scales are classified as accurate or inaccurate upon the basis of the tolerances adopted by the National Conference on Weights and Measures for used scales which, in general, may be said to be ±0.20 percent, applied to errors of the scale indications with respect to the standard-weight loads used. For a detailed statement of the tolerances, reference should be made to the material beginning on page 38 of this report.

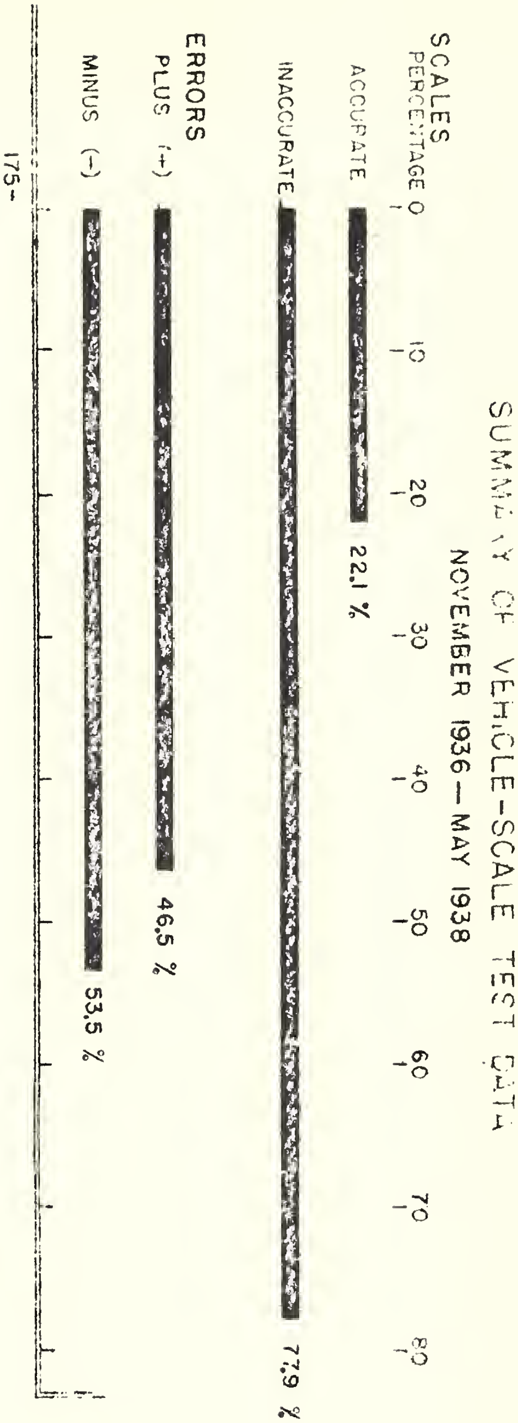
Table 1

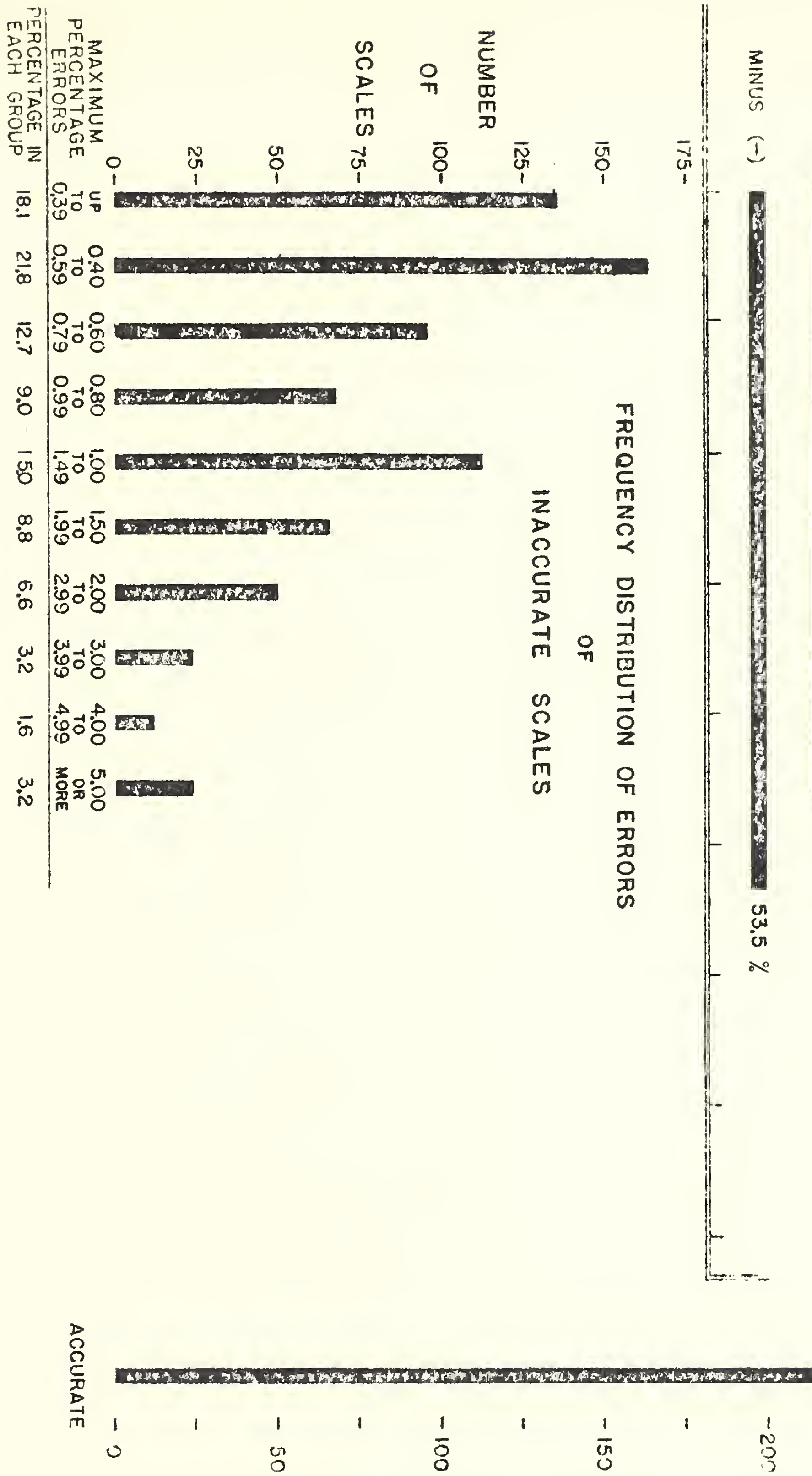
Vehicle-Scale Test Results by Type of Scale
November 1936 - May 1938

Type, Ownership, or Use	Number Tested	Found Accurate		Found Inaccurate		Numerical Mean of Maximum Percentage Errors
		Number	Percent	Number	Percent	
Wagon Scales	433	76	17.6	357	82.4	1.41
Motor-Truck Scales	534	138	25.8	396	74.2	1.04
State, city, town, or county	67	13	19.4	54	80.6	0.68
Coal or coke	582	125	21.5	457	78.5	1.16
Cotton or cotton products	129	35	27.1	94	72.9	1.38
Farm products, including fruit and sugar cane	62	18	29.0	44	71.0	0.83
Scrap materials	56	6	10.7	50	89.3	2.18
Stone, sand, or gravel	16	2	12.5	14	87.5	1.93
Public weighing	9	2	22.2	7	77.8	0.88
Miscellaneous	46	13	28.3	33	71.7	1.16
Totals	967	214	22.1	753	77.9	1.20

The foregoing table discloses that of the 967 vehicle scales covered by this report, only about 2 out of nine were found to be accurate, and that the mean of the maximum percentage errors of all of these scales was six times the basic tolerance allowable. Less than 1 out of 5 of all wagon scales were accurate, the mean percentage error of this group being about seven times the basic tolerance; of the motor-truck scales, only 1 out of 4 were accurate, the mean percentage error of this group being more than five times the basic tolerance. In the case of scales used for particular purposes, as many as 7 out of 8 were found inaccurate in each of two groups, and the mean percentage error of one of these groups was nearly eleven times the basic tolerance.

Test data are presented graphically on the following page, the graph being divided into two parts. On the upper portion of the graph are shown percentages of scales found accurate and inaccurate, and the percentages of scales having plus and minus errors; the latter data show that there was no significant difference in the numbers of scales found to be overweighing and underweighing. In the lower portion of the graph, maximum errors found on inaccurate scales have been classified on the basis of their magnitudes; in general, the frequency of errors is shown to decrease as their size increases. The scales found accurate are plotted at the extreme right of the graph for purposes of comparison with the error-distribution plot.


SUMMARY OF VEHICLE-SCALE TEST DATA
NOVEMBER 1936 — MAY 1938
SCALES
PERCENTAGE 0
10
20
30
40
50
60
70
80
ACCURATE
22.1 %
INACCURATE
77.9 %
ERRORS
PLUS (+)
46.5 %
MINUS (−)
53.5 %


FREQUENCY DISTRIBUTION OF ERRORS
OF
INACCURATE SCALES
NUMBER
OF
SCALES
0
25
50
75
100
125
150
175
200
MAXIMUM PERCENTAGE ERRORS
UP TO 0.39
0.40 TO 0.59
0.60 TO 0.79
0.80 TO 0.99
1.00 TO 1.49
1.50 TO 1.99
2.00 TO 2.99
3.00 TO 3.99
4.00 TO 4.99
5.00 OR MORE
PERCENTAGE IN EACH GROUP
18.1
21.8
12.7
9.0
15.0
8.8
6.6
3.2
1.6
3.2
ACCURATE

The scales reported upon above include twenty scales found to have maximum errors in excess of 5 percent of the applied test-weight loads; these errors range from 5.5 percent to 59.70 percent. If these twenty scales were to be disregarded because of their abnormally large errors, and if the mean errors were to be recomputed for the groups affected, the mean of the maximum percentage errors would be reduced as follows:

Table 2

Numerical Mean of Maximum Percentage Errors

Type, Ownership or Use	All Scales	Excluding 20 Scales having abnormally large errors
	Percent	Percent
Wagon Scales	1.41	1.01
Motor-Truck Scales	1.04	0.71
State, city, town, or county	0.68	0.68
Coal or coke	1.16	0.88
Cotton or cotton products	1.38	0.71
Farm products, including fruit and sugar cane	0.83	0.71
Scrap materials	2.18	0.92
Stone, sand, or gravel	1.93	0.93
Public weighing	0.88	0.88
Miscellaneous	1.16	1.06
Totals	1.20	0.84

An analysis of the test results discloses that weighbeams were found to be inaccurate in the case of more than one-fourth of the scales tested. These inaccuracies include faulty agreement among the several bars of a weighbeam on scales not utilizing counterpoise weights, inaccurate weighbeam indications independent of scale ratio errors on scales utilizing counterpoise weights, and inaccuracies of weighbeams subordinate to dials.

There were tested 112 scales which utilized counterpoise weights, such scales comprising 12 percent of the total number tested. These scales utilized a total of 599 counterpoise weights (exclusive of some weights designed for use on scales of low multiple), of which 247 weights, or 41 percent, were found to be accurate, 77 weights, or 13 percent, were found to be heavy, and 275 weights, or 46 percent, were found to be light.

Sensitiveness. There were 729 scales, or 75 percent of the total, to which SR requirements were applicable. Of this number, 7 scales, or 1 percent, were found to be in neutral or unstable equilibrium, 334 scales, or 46 percent, were not sufficiently sensitive, and 388 scales, or 53 percent, were found to have sensibility reciprocals within the prescribed limits.

Zero-Load Balance. Early in the testing program, it was decided to record the amounts, if any, by which scales were found out of balance at zero load. Such data are available on 925 scales. In 25 instances, or 3 percent, scale operators were found to be using one of the weighbeam poises to effect zero balance of their scales; although these scales were seriously out of balance when the poises were returned to zero, they have been considered, for record purposes, to have been in balance as found. However, 271 scales, or 29 percent of those for which data are available, were found out of balance at zero load by amounts in excess of five pounds, and these zero-balance errors ranged up to a maximum of 1020 pounds. It should be noted, however, that in some 12 instances, scales more or less seriously out of balance had not been in use for some time prior to the tests; if these scales be excluded from consideration, the maximum zero-balance error found was 265 pounds.

Validity of Tolerances Applied. A scale is said to be "accurate" or "inaccurate" according to whether it does or does not comply with some stated criterion which has been set up to define an "accurate" scale. The classification is valid only if this criterion is a proper one -- if the requirement for accuracy is unnecessarily rigid, if it cannot be reasonably obtained in good practice, then the figures given and the conclusions based thereon should be discounted accordingly.

In the foregoing presentation it has been noted that scales are classified as accurate or inaccurate upon the basis of tolerances adopted by the National Conference on Weights and Measures. In view of the very large percentage of scales which are classified as inaccurate it appears to be desirable at this point very briefly to consider the general validity of these tolerances. While this is probably unnecessary in the case of weights and measures officials and others entirely familiar with the performance of scales, it may be of benefit to those readers not so well informed along these lines.

It may be said then, that the National Conference tolerances for scales have been developed over a period of many years and in general represent the consensus of a very large group of informed persons not only in the Conference but in other groups working independently along parallel lines. The viewpoints of many different interests have been represented. These interests include weights and measures officials, railway and industrial scale men, representatives of scale manufacturers, of weighing and inspection bureaus, of boards of trade and chambers of commerce, of shippers and carriers, and of Federal Government agencies. It is believed that these interests are practically unanimous in their endorsement of the basic tolerances for large-capacity scales.

It may be said further that after a considerable amount of data had been gathered in the present investigation of vehicle scales, the tolerances on vehicle scales were somewhat liberalized in their detail requirements by the National Conference without changing basic figures, so that scales which were originally found not to comply with the tolerances in all respects but which were deemed to be of satisfactory accuracy would be transferred from the inaccurate to the accurate class. All figures in this report are based on compliance or noncompliance after the tolerances were thus liberalized.

Again it may be said that while there is some sentiment to the effect that the tolerances for vehicle scales are not entirely satisfactory in every detail, this dissatisfaction largely centers around the liberalization mentioned above; in other words the criticism is that the tolerances are now too large rather than too small. This matter will be considered later in this report.

All of the above strongly points to the fact that the tolerances are not too rigid. Finally there is a tremendous amount of data which can be adduced further to support this point of view, and the fact that compliance can reasonably be attained. The data referred to are those collected by the Railway Track Scale Testing Service of the Bureau.

Essentially railway track scales and many motor-truck and some wagon scales are similar mechanisms, differing primarily only in capacity and number of sections; other wagon and some motor-truck scales, while differing from the ordinary railway track scale in pattern, are nevertheless designed for weighing large-capacity loads. Basically the tolerances for railway track scales and for vehicle scales are the same, 0.20 percent of the applied load, for scales in use. However, adequate tests have been regularly made by their owners or other agencies on the majority of railway track scales for a number of years, while adequate tests have not been made or have not regularly been made on the very great majority of vehicle scales tested by the Bureau.

In the fiscal year 1914 the Bureau inaugurated an investigation of the condition of railway track scales throughout the United States. The number of tests made to July 1, 1938, approximates 20,000. In the fiscal years 1914-1915, it was found that only 33 percent of the scales tested were accurate; the mean percentage error was 0.57 percent. In the fiscal year 1933, in which year the highest percentage of scales found accurate was realized, 80.6 percent of the scales tested were accurate; the mean error was 0.17 percent. The figures of 1914-15 indicate the serious condition which existed in respect to these scales before adequate tests were generally made; the improvement over the ensuing period of 18 years shows what can be accomplished by proper attention; the figures for the fiscal year 1933 indicate that it is entirely practicable to maintain large-capacity scales within a basic tolerance of 0.20 percent.

It may be concluded from all the above that there is nothing fundamentally wrong with the tolerances applied in the investigation of vehicle scales and that the classification of accurate and inaccurate scales in this report is a valid one.

Loads weighed. Many and serious instances of overloading of scales have been disclosed. There appears to be little appreciation on the part of scale operators, of suitable limitations on the sizes and character of vehicle loads weighed on their scales, particularly when the scales are of the wagon type. It is very well recognized by scale manufacturers that wagon scales should not be used for the weighing of motor-truck loads in excess of sixty percent of their nominal capacities, and many wagon-scale weighbeams are marked to show this limitation. Yet the overloading of wagon scales with respect to this criterion has been recorded in the case of 63 percent of the 433 wagon scales tested, or 273 scales; 69 scales, or 16 percent, have been subjected to motor-truck loads equalling the "wagon" capacities of the scales, and motor-truck loads in excess of nominal "wagon-scale" capacities have been reported in the case of 20 scales, or 5 percent of the wagon scales tested. Maximum overloading was reached in the case of a 12,000-pound scale used for weighing 18,000-pound motor-truck loads.

The weighing on motor-truck scales of motor-truck loads in excess of the nominal scale capacities has been reported in 32 instances, or 6 percent of the motor-truck scales tested.

The Bureau's test of a wagon scale conforms to the method of use contemplated by the scale manufacturer and does not disclose the weighing results which follow when the scale is subjected to large motor-truck loads. Quite naturally, in the test of any scale, the scale is not loaded beyond its nominal capacity. It follows that the Bureau is without information as to the magnitude of the errors which may have developed under the conditions of overloading discussed above.

Following the adoption by the National Conference in 1937 of the regulation to the effect that vehicle scales should not be used for the weighing of loads of less than 1000 pounds, there were recorded the minimum loads being weighed on the scales tested. Such data are available for 340 scales. It was found that 157 scales, or 46 percent of those reported upon, were being used to weigh loads of less than 1000 pounds; on 111 of these, or 33 percent of the total, the minimum loads weighed were 100 pounds or less. The smallest load recorded was 10 pounds, reported in two instances.

Results of Inspection. The inspection of scales, particularly as to conditions in the pits, continues to be an essential element of every test conducted by the Bureau's testing unit whenever such inspections can be made. Unfortunately, poor accessibility to the lever system, or the presence of an excessive amount of water or foreign matter in the pit, or a combination of these conditions, not infrequently makes it impracticable to conduct a proper inspection of the scale parts in the pit, or entirely precludes such inspection. Either no pit inspection at all, or only partial inspection, could be made in the case of 105 scales, or 11 percent of those tested.

Before the presentation of a summary of the faulty conditions of installation and maintenance disclosed by the inspections of vehicle scales, mention might be made of a few of the unusual conditions which have been found. In two instances, water has been found in weighbeam poises. A weighbeam load bearing steel was installed upside down. Two scales constructed with wooden levers were encountered. The lead seal of approval of the weights and measures official had been affixed to the main weighbeam poise of one scale. A balance-ball assembly had lost motion equivalent to a platform load of approximately 130 pounds. The truss post of a trussed main lever was entirely disengaged and was lying on the bottom of the pit. In the repair of a broken lever, the nose-iron had been welded to the lever. A weighbeam face-plate was incorrectly marked, the indication "11,000" appearing between the indications of "8,000" and "10,000". An overhanging "track" had been mounted on a scale platform for the purpose of weighing long vehicles on a short scale. A lever system was so badly out of alinement that the extension-lever tip pivots would not remain on their bearings. A cardboard shim, used in the poise slot to improve the weight impressions of a type-registering weighbeam, was regularly left in position, thus making the poise heavy. A unit weight and the dial at capacity were found out of agreement by 100 pounds.

Proceeding now to a statistical consideration of faults of installation and maintenance, three conditions may be said to be definitely associated with installation, namely, accessibility, pit drainage, and scale approaches, while many other faulty conditions reported may be caused primarily or partially by poor

installation and may be partly caused or may be aggravated by poor maintenance. Percentages given below are based, whenever this is considered justified, upon the total number of scales tested; in other cases, the percentages are based upon the number of scales to which the condition under consideration is applicable or on which the particular condition could be determined.

Accessibility to the scale parts in the pit for purposes of inspection and maintenance is reported for all but three of the scales tested. Conditions are reported as "bad" for 18 scales, or 2 percent, as "poor" for 198 scales, or 21 percent; as "fair" for 398 scales, or 41 percent, as "good" for 338 scales, or 35 percent, and as "very good" for 12 scales, or 1 percent.

Scale lever systems were installed below the surface of the ground in 954 instances. No provision had been made for pit drainage, or it could not be determined that such provision had been made, in the case of 554, or 58 percent, of these installations.

Approaches to scales, which should be smooth, straight, and in the plane of the scale platform for a reasonable distance from each end of the scale, were reported as "rough" in 79 installations, or 8 percent, and as "curved" in 174 installations, or 18 percent. Disregarding "slight" inclines, 473 scales, or 49 percent of those tested, were found to have one or both of the approaches inclined to the scale platforms, the approach in most cases sloping upward to the platform; in 157 of these cases, or 16 percent of all scales tested, the gradients were 5 percent or more, the maximum incline reported being 30 percent.

Water was found standing in the pit, or the pit drain was reported clogged, in the case of 163 scales, or 17 percent. Scale pits were dirty in 405 cases, or 44 percent; in many cases the accumulations of dirt, coal, or other foreign matter were sufficient to cause interference with the lever systems, and in some instances one or more levers were literally buried.

The structural steel in the pit has been found to be rusting in the case of 258 scales, or 29 percent.

No provision had been made for protection against corrosion of the pivots and bearings of the lever system in the case of 411 scales, or 44 percent of the scales on which this condition could be determined, and in the case of 51 additional scales, or 5 percent, only a part of the pivots and bearings were protected.

The pivots and bearings were found to be rusting or dirty or both in the case of 444 scales, or 50 percent. Pivots and/or bearings were found to be worn in the case of 165 scales, or 19 percent. Undoubtedly there were many instances of badly worn pivots and bearings which were not reported, because of the impracticability, under prevailing pit conditions, of determining the actual state of these parts. Pivots were found to be displaced from proper position on their opposing bearings in the case of 129 scales, or 15 percent. Pivots or bearings were reported to be broken in 13 instances, 2 cases of missing pivots were reported, and there were numerous instances in which the antifriction plates were found to have been broken off.

Bearing assemblies or connections, including beam rods, were found to be out of plumb in the case of 358 scales, or 40 percent. Levers were reported to be out of level in the case of 227 scales, or 26 percent. There was actual interference with elements of the lever system in the case of 112 scales, or 13 percent; a like number of cases were reported in which clearances around elements of the lever system were inadequate. Faults associated with lever stands or with supports for suspended levers were reported in the case of 52 scales, or 6 percent. Faults associated with lever foundations were reported in the case of 36 scales or 4 percent. Levers, lever extension arms, or T bearings were found to be loose in the case of 32 scales, or 4 percent. One broken lever was found in service, and several instances of defective weighbridge girders were reported.

Faults associated with the platform checking means were reported in the case of 108 scales, or 12 percent. Clearances between scale platform and coping were found to be either too large or too small on 311 scales, or 32 percent. Repairs were needed on the platforms of 212 scales, or 22 percent. Surface alinement between scale platform and coping was faulty in the case of 96 scales, or 10 percent.

The weighbeam parts of 229 scales, or 25 percent, were found to be dirty, rusting, or tarnished. Mechanical faults associated with weighbeam assemblies, such as worn or missing poise pawls, battered zero stops, defective trig loop assemblies, etc., were reported in the case of 163 scales, or 18 percent. Weighbeam or automatic-indicating elements were found to be loosely or insecurely mounted in the case of 143 scales, or 16 percent. Clearances were inadequate around beam rods in 55 installations, or 6 percent. Many weighbeams were found to be out of level, that is, not horizontal when the weighbeam tip was at the center of the trig loop. Seven instances of interference with a weighbeam were reported.

Interferences in automatic-indicating mechanisms were reported in the case of 50 scales, or 22 percent of the number equipped with automatic-indicating elements. The indications were partly illegible or otherwise faulty in the case of 17, or 7 percent, of the scales which were essentially "automatic-indicating" scales. Six instances of mechanical faults associated with unit-weight mechanisms were reported.

NEWLY-INSTALLED MOTOR-TRUCK SCALES

There are now to be presented certain facts developed in relation to newly-installed motor-truck scales which are so extraordinary as to merit most careful study by all the manufacturers and installers of vehicle scales and by all the officials in charge of the administration of weights and measures laws in the United States.

Dates of Installation. Among other data obtained by the Bureau inspectors are the dates of installation of scales tested, whenever this information can be procured. A number of scales tested are reported to have been installed very shortly after the date at which the type of scale known as the motor-truck scale, as distinguished from the wagon scale, first came on the market, in 1912 or 1913. Motor-truck scales have been encountered that are reported to have been installed in every year since that date to the present time. Naturally many of the older scales have not received proper maintenance throughout the years. Thus, whether through age or through failure on the part of the owners properly to care for them or as a result of both factors working in unison, many of these scales are in bad condition.

However, in the last several years a large number of new motor-truck scales have been installed. Apparently many were sold in 1934, 1935, 1936, and 1937, and thus many of the scales tested had been installed during these years. As a result the average age of the motor-truck scales tested is not as great as might be supposed. At one stage of the investigation it was determined that the average age of motor-truck scales tested to that date was some 8 years. It would be supposed that the accuracy of the scales recently installed would tend to offset the inaccuracy of scales installed many years ago. In the case of very recent installations, even if the owner were failing properly to maintain his scale, this would have a very much less marked effect on its mechanical condition and its accuracy, than in the case of older installations. It was decided then, that it would be of value to determine the accuracy of motor-truck scales installed only shortly before they were tested by the Bureau equipment.

For this purpose data were computed on scales installed in the same calendar year, and in the calendar year preceding the year, in which they were tested by the Bureau equipment. The average age of scales of the first group would be about six months, of the second group about 18 months, and of the combined groups somewhat over 12 months. It was found that there were involved 71 scales, or some 13 percent of the motor-truck scales tested, enough to make the results of value; 23 scales or some 4 percent of the motor-truck scales tested were in the first group and 48 scales, or about 9 percent, in the second.

Accuracy. The data on accuracy of newly-installed motor-truck scales have been arranged in the table which follows:

TABLE 3

Test Results on Newly-Installed Motor-Truck Scales

Date of Installation	Number of Scales	Accurate	Percent	Inaccurate	Percent	Mean of Maximum Percentage Errors
In same year as test	23	4	17.4	19	82.6	0.67
In year preceding test	48	15	31.2	33	68.8	0.54
Totals	71	19	26.8	52	73.2	0.58
All remaining motor-truck scales	463	119	25.7	344	74.3	1.11

The above figures indicate that of motor-truck scales tested by the Bureau in the same calendar year as that in which they were installed -- an average period of some six months having elapsed since installation -- about one motor-truck scale in six was found to be accurate within prescribed tolerances; the mean error of these scales was almost 3 1/2 times the basic tolerance.

Of the motor-truck scales tested in the calendar year following that in which the scale was installed -- these scales would have averaged some 18 months in service -- something less that one motor-truck scale in three was accurate, the mean error of these scales being more than 2 1/2 times the basic tolerance.

Of the combined groups -- installed on the average somewhat more than 12 months prior to the test -- about one scale in 4 was accurate, and the mean maximum error was some three times the tolerance.

The figures just given are to be compared with the general accuracy of the remaining motor-truck scales, the figures for which are appended to the table above. The almost unbelievable conclusion is demonstrated that insofar as percentage of scales accurate is concerned, the new installations are not substantially better than the general average installation. Only when the figures representing the mean of maximum errors are compared are the new installations found to be substantially more accurate than the old. The mean error for the former group is 0.58 percent or approximately one-half the mean error of 1.11 percent for the latter.

Some figures in relation to SR's may be of value. It is found that of 50 scales to which the maximum SR requirements were applicable, 28 scales, or 56 percent, complied with the appropriate requirement for scales in use; the remaining 22 scales, or 44 percent did not so comply. Of the 15 scales in this group which are classified as accurate, 11 scales, or 73 percent, complied with the requirement; of 35 inaccurate scales, 17 scales, or 49 percent complied. In the case of the accurate scales, those not complying exceeded the maximum value allowed by an average of 5.5 pounds; the average excess of 17 inaccurate scales was 10 pounds, one inaccurate scale being in unstable equilibrium.

The general figure of 56 percent of newly-installed scales complying with SR requirements may be compared with the similar figure for all remaining motor-truck scales; this figure is 53 percent.

While few of the accurate scales were so recently installed as definitely to put them in the class of "new" scales, it will be of interest to determine how many of them complied with the requirements for new scales. It is found, then, that of 19 scales listed as accurate only 6 or some 32 percent were within the manufacturer's tolerance or tolerance on new scales, while 13 or 68 percent were not within this tolerance. Seven, or 44 percent of the 16 of these scales to which the SR requirement was applicable, complied with the SR requirement for new scales; the remaining 56 percent did not. Finally, only 2 scales, or 12.5 percent of these 16 scales listed as accurate, complied both with the SR and tolerance requirements applicable to new scales.

<u>Condition of Scales</u>. The general accuracy figures, the general condition surrounding the installations, and the condition of specific scales very recently installed prove beyond peradventure that a great many new motor-truck scales are being turned over to their owners in improper and inaccurate condition. This is a severe indictment of the interests responsible for the installation of motor-truck scales. It is believed that the manufacturers of the scales turn out from the factory a satisfactory product. While this is a necessary and indispensable contribution toward satisfactory conditions it by no means tells the whole story. If in the installation of the scale the original accuracy is destroyed, the fact that, as manufactured, the scale was an excellent one is of little consolation to the purchaser who is furnished with an inaccurate weighing machine installed in the pit. It is apparent that until conditions such as these shall have been rectified, there is no logical basis for the slightest hope that a satisfactory accuracy of motor-truck scales in use can be realized.

It is not intended to be suggested by the above that every new scale is subject to serious installation faults. It is emphasized, however, that in far too many cases inexpert installation is demonstrated by inspection. Several specific examples may be cited.

The following faulty conditions were found on inspection of a scale which had been installed only about four weeks prior to the time the Bureau inspectors visited it. The trig loop at the tip of the weighbeam was installed in reverse position. The beam rod was considerably out of plumb. Two main load bearing assemblies were out of plumb. A main-lever fulcrum stand was improperly installed; it appeared that the anchor bolts had not been correctly positioned and that these had been bent to bring the fulcrum stand into approximately correct position, as a result of which the stand was not plumb. This stand was also improperly grouted and had a bearing on the foundation equivalent to only about half the area of the base of the stand. As a result the main lever was thrown out of proper position and there was interference between the tip of the lever and the tip connection. The maximum percentage error on this scale was +0.89 percent.

In the case of another scale turned over to the purchaser not more than six weeks before the test was made, the following conditions were reported: Main levers and the transverse extension lever were loose. A main fulcrum stand was not anchored, being neither bolted nor grouted to the pier. Another fulcrum stand was mounted on a board placed on top of the foundation pier, and the stand was out of plumb. The connection at the tip of a main lever was out of plumb. Two anchor bolts for one of the check elements were missing. Parts were improperly positioned, as a result of which main bearings were displaced from proper position on their opposing pivots and were interfering with the main levers. The beam rod was slightly out of plumb. One corner of the scale platform was approximately 3/4 inch below the level of the coping. The weighbeam shelf was not rigidly mounted. The maximum percentage error on this scale was +1.08 percent.

The next scale to be cited had been in use one week. Main levers and a reversing lever were somewhat out of level. Clearances between scale platform and coping were inadequate. Under load there was a tendency for the weighbridge to shift its position such that under a 15,000-pound load at the left end of the scale there was slight interference between scale coping and scale parts. The foundation for the weighbeam assembly was not rigid and the weighbeam shelf was very loosely mounted. The maximum percentage error on this scale was found to be -0.33 percent.

There is now to be considered a scale in use some 8 months. In this case inspection disclosed that the transverse extension lever was improperly mounted, as a result of which there was probably some interference around the fulcrum pivots. One main lever appeared to be improperly positioned, causing interference in the connection at the tip of the lever. This scale had a maximum percentage error of -1.12 percent.

The next scale was installed about four months prior to the Bureau test. It was found on inspection of the scale that this had been well installed except that two main load bearing assemblies were badly out of plumb. This condition was so bad that when a 15,000-pound load was applied to the right end of the scale, this caused the platform to shift to the near side into contact with the coping; when this load was removed the scale platform returned to its former position. This condition was undoubtedly caused by improper positioning of parts. At the conclusion of the test there was a zero balance change of +20 pounds. The maximum percentage error in this case was +0.30 percent.

Another scale had been in service about four weeks. Before the test was started the weighbeam balance ball assembly was raised in an effort to reduce the SR of the scale to a value within the prescribed limit; this adjustment, however, only reduced the SR from 20 pounds to 15 pounds at zero load, and at a 15,000-pound load the scale was found to have a 20-pound SR. The maximum allowable SR was 10 pounds. The following faulty conditions were found upon inspection: Wood supports had been utilized between lever stands and concrete foundation piers. Two main levers were loose. Main levers and the transverse extension lever were somewhat out of level. The connection at the tip of one main lever was badly out of plumb. There was some interference around three of the main load bearings. The beam rod was somewhat out of plumb. Old planking had been used for the scale platform and this was rough. Approaches to the scale were rough. A maximum percentage error of -0.57 percent was found.

There is now encountered a scale the installation of which had just been completed. It was found upon inspection that the beam rod was slightly out of plumb and that both of the weighbeam extension levers were badly out of level. The nose iron of the transverse extension lever appeared to have been moved from the position determined by the factory sealing operation, apparently in an effort to plumb the connection between the transverse extension lever and the first weighbeam extension lever. The second weighbeam extension lever had been broken and temporarily repaired. Other levers in the pit were slightly out of level and one load bearing assembly was somewhat out of plumb. Before the application of the strain load the scale was found to have shifted its zero balance by -15 pounds; it was rebalanced before the test was continued. At the conclusion of the test a further balance shift of -16 pounds was noted. During

the progress of the test the weighbeam balance ball assembly was raised to the upper limit of its travel, thus reducing the SR of the scale from 20 pounds to 14 pounds on a gross load of approximately 30,000 pounds. The maximum allowable SR was 10 pounds. The maximum percentage error was +0.45 percent.

The next scale had been in use 8 months. The following faulty conditions were found on inspection: The main levers were out of level. At one end of the scale, parts were not properly alined and there may have been interference resulting from this condition. The transverse extension lever was improperly mounted, with possibility of interference around the fulcrum pivots of this lever. The weighbeam shelf was not rigidly mounted and was out of level, and in consequence the weighbeam assembly was also out of level. The maximum percentage error developed was +0.67 percent.

The next scale had been installed about 9 months. It was found on inspection that the lever foundations were in bad condition; at one point the concrete was broken and crumbling badly. A main lever and the weighbeam extension levers were out of level. One main load bearing assembly was out of plumb. Loose balancing material was found in use at both the butt and the tip of the weighbeam to effect the zero balance of the scale. The approach at the left end of the scale was sharply inclined to the scale platform and the concrete surface was in bad condition. At the conclusion of the test the scale was found to have shifted its zero balance by +35 pounds. Before the test was started the weighbeam balance ball assembly was raised to the upper limit of its travel; this resulted in reducing the SR from 20 pounds to 15 pounds at zero load. The maximum allowable SR on this scale was 10 pounds. The maximum percentage error determined was +0.37 percent.

The last scale to be mentioned was installed by a city as a public scale 9 months before the test. To correct this scale, which had a maximum percentage error of -0.24 percent, the following steps were taken: The connection at the tip of one main lever was brought into proper vertical alinement, a loose main lever was tightened, the weighbeam balance ball assembly was raised in an effort to reduce the SR of the scale, the fractional weighbeam poise was adjusted, and nose-iron adjustments were made.

In order that it may be perfectly clear that the above 10 scales do not represent some unusual condition in some particular section of the country, it may be said that the scales in question were located in 9 different States. Three of the scales were automatics, the remaining seven being beam scales. Five each were of straight-lever and torsion-lever type of construction. Six of the scales were installed by manufacturers' representatives; of the remaining four, two were said to be installed by "contractors", one by a "local scale man", and one by "owner". The average period elapsing since installation of

all of these scales was slightly over 4 months. The numerical average of the maximum percentage errors was 0.60 percent -- three times the basic tolerance allowable.

Remedies Suggested. In view of the facts which have been detailed it should be apparent that it is imperative that fundamental and thoroughgoing improvements be effected if present conditions are to be corrected. Two concomitant remedial steps are offered for consideration.

First, adequate official inspections and tests must be provided for and they must be promptly and unrelentingly carried out and applied to all new installations. Inspections might well begin during the progress of the work; upon its completion a final complete inspection and a thorough acceptance test should be made so that the purchaser can be assured that the new scale has been properly erected and is weighing accurately before the purchase contract can be considered as complete. In ordinary cases involving contracts the old legal maxim of "Caveat emptor" --"let the buyer beware"-- may be applicable; the buyer must satisfy himself as best he can that he has procured that which he has contracted for and must suffer if he fails to do so. However, scales to be used for commercial purposes may be said to be in a quasi-public status. Inasmuch as the owner may be liable to criminal prosecution for the use of a weighing machine not conforming to the official standards set up, there is certainly a moral responsibility on the State to protect the purchaser from unwitting violation of the law.

Second, the interests responsible for installations must be built up to a very much higher plane of efficiency than appears to obtain at present. It can not be too strongly emphasized that a thorough housecleaning is in order. When the installation is made by the manufacturer it behooves him to make certain that the care exercised in the production in the factory will not be nullified by careless or inexpert work on the job. When the installation is made by the buyer or by a local scale man the responsibility is divided and it is not so easy to suggest how matters can be improved -- but improved they should be. Perhaps the situation could be ameliorated by the passage of laws requiring the licensing of scale installers and repairmen, a subject which has recently had considerable attention from scale men. A proper law intelligently administered might be found helpful in improving workmanship in both of the instances mentioned above. Additional safeguards come to mind. The manufacturer, it seems, might furnish with each scale detailed general and special instructions as to installation to guide the man on the job, whether or not this man is his employee, the employee of the owner, or an independent contractor. He might furnish a booklet containing suggestions as to proper maintenance to assist the owner to keep his scale in satisfactory condition, and he should emphasize the importance of this.

Finally he would furnish a worthwhile service if he would carefully check over the completed job whether it is his responsibility or that of another, and follow it up until assured that everything is in order.

The two remedial procedures mentioned above should be pushed forward at the same time. Neither the one nor the other can confidently be depended upon to secure the results desired. The inspection and test by the official can not of itself be sufficient, in the very nature of things. It is not the function of the State to install scales; the State is charged only with the duty of seeing to it that they are correctly and accurately installed. Even if general improvement in installation practices is brought about, this will not insure accuracy in the case of any particular job; moreover, it can not be determined what success is being attained by the second agency without the interposition of the first. Faulty installations will still be encountered; moreover the installer will not ordinarily have the sufficient load of test weights to enable him authoritatively to certify that the scale is weighing accurately at all points. Public policy and efficiency both demand that an adequate testing equipment and a competent certification of accuracy be furnished by the government authorities.

METHOD OF TEST AND INSPECTION OF VEHICLE SCALES DEVELOPED BY THE BUREAU

The method employed in testing scales with the Vehicle-Scale Testing Unit of the National Bureau of Standards is being set out herein, since it is felt that the subject of test methods in the case of this type of scale is one of increasing importance. Many States and local jurisdictions are acquiring equipment utilizing an adequate test-weight load and such equipment should be used to the best advantage.

The Bureau method has been developed over a period of time with the object in view of demonstrating the type of test best adapted for an accurate and thorough check of the performance of a vehicle scale, under such loads, and with such distributions of load, as are likely to be encountered in service. Necessarily, the number of such loads applied during a test must be limited to an essential minimum, in order that an excessive amount of time will not be taken for each test.

Preliminary Inspection of Scale. In testing vehicle scales with a large load of heavy test weights, and especially when a heavy strain load is used in combination with these, it is, of course, important to make certain that the scale to be tested is sufficiently strong to stand the total load to be applied during the test. If there is doubt that the foundation, weighbridge structure, or lever system may be strong enough to stand a test to the rated capacity of the scale, it is best to inspect these parts before making the test, and if necessary, then so to limit the applied load that the scale will safely support it.

Testing Equipment. The National Bureau of Standards Vehicle-Scale Testing Unit consists of a three-axle, dual-tired tandem-drive motor truck of approximately 40,000 pounds maximum gross weight, carrying fifteen one-thousand pound test weights, two sets of smaller weights, and the tools and accessories necessary in the operation of the equipment. The thousand-pound weights are handled three at a time by a horizontal boom crane, fully power-operated by power take-off from the truck engine. After the weights are unloaded from the truck, they are handled by means of a conventional two-wheel, rubber-tired, cart which can be easily manipulated on a smooth and level surface by one man.

One of the small sets of weights carried as part of the equipment is a set totalling 100.5 pounds, including three 20-pound, two 10-pound, two 5-pound, four 2-pound, two 1-pound, and one half-pound weights. This set of weights is used on the scale platform for determining scale errors by the balancing-weight method, the first step in the test of a vehicle scale being to place 50 pounds of these weights on the platform and then to balance the scale with all indicating elements set at zero. This permits the determination of errors throughout a range of plus or minus 50 pounds, by manipulation of the balancing weights. On most vehicle scales, except automatic-

indicating scales having 20-pound minimum graduations, or very insensitive beam scales, errors are determined with the balancing weights to the nearest pound.

The other small set of weights is a set of Monel-metal counterpoise test weights. The test counterpoise weights are used on the weighbeam counterpoise hangers during the regular test of beam scales designed for use with removable counterpoise weights. The counterpoise weights supplied with the scale are then checked for accuracy by means of an equal-arm, portable balance sensitive to one-half grain. The counterpoise test weights are specially adjusted to one-fifth Class C tolerances for this purpose.

General Test Procedure, 0 to 15,000 Pounds. The normal procedure in testing a beam scale of twenty-tons motor-truck capacity is this: First, the zero-load balance of the scale is noted; 50 pounds of balancing weights are then placed on the platform, and the scale is rebalanced with all indicating elements set at zero. The zero-load sensibility reciprocal is then determined by adding the required number of small weights to the platform. The 1000-pound weights are then lowered in groups of three to the platform, readings generally being taken at 3000, 9000, and 15000 pounds. The weights are applied as nearly symmetrically as is practicable with respect to the longitudinal center line of the platform, so as to give a balanced end test. Next, the test weights are shifted to an approximately distributed load over the platform, usually this being most conveniently accomplished by shifting eight test weights down to the second end of the scale, leaving seven weights at the first end. After taking a reading at this load, an SR determination is also made. Then the remaining test weights are shifted down to the second end of the scale, and a reading is taken at 15,000 pounds; readings are also taken at 9000 and 3000 pounds as the test weights are removed from the platform and placed in such positions, in groups of three, that they may readily be loaded into the test truck.

A reading is taken on the main bar of the weighbeam at all of these loads, and in addition, readings are taken on the tare bar, if the weighbeam is equipped with a tare bar, at two points, preferably at or near capacity of the tare bar, and at some intermediate load. For a tare bar of a capacity of 15,000 pounds or more, the points at which readings are usually taken are 3000 and 15,000 pounds.

If the scale has a fractional bar of 1000 pounds capacity (or 990 pounds, as is usually the case if the scale has a type-registering weighbeam) the fractional poise is checked directly against a 1000-pound load on the platform. Scales having 500-pound fractional poises are checked at any of the regular test loads by checking the main fractional poise against a main-bar notch, and the tare fractional poise against a tare-bar notch.

General Test Procedure, Strain Load. After the test weights are removed from the scale the zero balance is checked; then the empty test truck is driven on the scale for a strain load. No attempt is made to use the test truck as a standard test-weight load, since large variations in its weight will occur, due to variations in the quantity of gasoline in the tanks, dirt on the wheels and chassis, tire wear, and change in the amount of baggage. The test truck is used simply as a heavy strain load, and its only change in weight during a strain load test will be due to the amount of gasoline consumed in reversing the truck on the scale, and in loading the test weights into the truck. The weight of gasoline consumed during these operations is accurately determined by running the engine on gasoline drawn from a special 22 1/2-pound capacity compartment built in one of the regular gasoline tanks. This compartment is equipped with a gage glass calibrated in pounds, so that the total amount of gasoline consumed during the strain load test is readily determined by the difference in the gage readings taken at the beginning and at the end of this test. The weight of gasoline consumed in this procedure is from three to five pounds in most cases.

On scales of 20- to 24-foot platform length, the test truck is balanced out in two positions, with the rear axle at either end of the scale. With the empty truck balanced out as a strain load on the scale, the test weights are then loaded into the truck, thus in effect reapplying the 15,000-pound test-weight load to the scale, which carries the total load on the scale up very close to its capacity of twenty tons. The scale error at this load, that is, the error of the scale in registering the net load of 15,000 pounds which has been added to the strain load, is determined. An SR reading is then taken, then the truck is reversed on the scale and the reading for scale error with the rear axle at the other end of the scale is taken.

On scales over 24 feet in length and less than 34 feet in length, it is desirable to make strain load tests with the rear axles as near the center of the platform as possible, in addition to the two spots with the rear axle at each end of the platform. In such tests, the truck is balanced out in four different positions, as follows: First, with the truck rear axle at first end of scale; second, with the truck moved forward until the front axle is at the second end of the scale, at which position the rear axle will be at some point intermediate between the center of the scale and the first end of the scale; third and fourth, these same two relative positions of the truck, respectively, except that the truck is reversed.

On scales with platform lengths of 34 feet or longer, it is possible to place the rear axles at the center of the platform, hence only three positions are utilized for the strain load, right, left, and center. The "center" position strain load may be made with the front of the truck either to the right or left. It is important, however, that for all strain load observations, the truck be placed in as nearly as practicable the same positions loaded as it was when balanced out in the various positions empty.

The strain load test with rear axle at or near the center of the platform of long platform scales is particularly valuable in finding the source of errors of such scales as have defects in weighbridges, faulty weatherguard installations, and, in some cases, faults in the lever system also.

Since a platform length of at least 20 feet is required for the test truck, it is not used as a strain load on scales having a platform length of less than 20 feet. In such cases, any available heavy short-wheelbase truck is utilized, the weights being loaded on the scale either with the crane or by means of the handling cart. A scale with insufficient overhead clearance for the test truck requires a similar procedure, though the crane cannot of course be used for reapplying the test weights.

At the conclusion of every test the zero balance is checked.

Modification of Procedure for Automatic-Indicating Scales. On automatic-indicating scales of the dial type, the above procedure is modified in several ways. In order to check the accuracy of the dial mechanism adjustment throughout the range of the dial, it is necessary to add the test weights to the platform one at a time up to the dial capacity, taking readings at each of these loads. The first unit weight is then checked, after which test weights are added in increments equal to the dial capacity, thus checking each unit weight, up to the available test load of 15,000 pounds. The strain load is then applied, and the test weights are loaded into the test truck, also in increments equal to the dial capacity, thereby checking all unit weights, insofar as practicable, directly against test weights on the platform.

On beam-type scales equipped with automatic-indicating devices, the testing procedure is the same as with the usual beam-type scale, except that a reading of the device, as well as a beam reading, is taken at every load within the capacity of the device, the device serving simply as a balance indicator in the case of all readings taken on the beam.

Modification of Procedure for Wagon Scales. Wagon scales are usually tested with the test weights only, strain loads not ordinarily being required. Wagon scales are never tested with an end loading exceeding 50 percent of the capacity of the scale. For convenience in handling the weights in groups of three, the end loading utilized on a 20,000-pound wagon scale is generally limited to 9000 pounds. In no case is the total test load carried materially beyond the rated capacity of the scale, even though in the case of some wagon scales the motor-truck loads weighed in service on these scales have far exceeded the motor-truck ratings, and in some instances even the wagon ratings.

Inspection. Whenever practicable, after each test, a complete inspection of the scale is made. In this inspection, the general condition of the lever system, foundation, weighbridge structure, and foundation for the indicating elements is checked; inspection is made for dirty, worn, or rusted pivots and bearings, binds of any kind, out-of-plumb connections, out-of-plumb bearing assemblies, loose levers, loose or incorrectly positioned fulcrum stands, incorrectly alined ball-check plates, out-of-level levers, loose extension arms on torsion levers, and close clearances at any part of the scale. Of course, any accumulation of foreign matter in the pit is noted. The weighbeam assembly is checked to see that it is rigidly mounted, this being especially important on scales of the automatic-indicating type or those equipped with an automatic-indicating attachment. The weighbeam assembly is checked for level, for cleanliness particularly of the notches and poises, for worn or battered poises and stops, for worn notches or pawls, and for weak or broken pawl spring in the main poise.

In each inspection the performance of the scale as shown by the test is kept in mind since this, of course, aids in finding the faulty conditions which adversely affect the weighing performance of the scale. The strain load test is frequently of particular value in indicating faulty conditions of the pivots and bearings, faulty foundations, faulty weighbridge structure, and, especially on automatic-indicating scales, weak or sagging foundations for the indicating elements.

Field Records. All test observations are recorded on a test record form. An inspection record form is used for recording all essential data about the scale, its make, type, capacity, capacities of the various indicating elements, platform size, type of lever system, type of foundation, as well as any faulty conditions found during the inspection.

General Considerations. For the efficient operation of a vehicle-scale test truck such as the one operated by the National Bureau of Standards, two men are required. With this equipment it is usually possible to make the complete test of a 20-ton motor-truck scale in approximately one hour. Smaller scales require much less time for the test, usually from 25 to 45 minutes if a strain load test is not required. These periods of time do not, of course, include the time required for a complete inspection in the scale pit, which will require an additional period of from 10 to 30 minutes. The time required for a pit inspection is largely determined by the accessibility of the lever system. Unfortunately at the present time there are relatively few vehicle scales which have what could be called satisfactory accessibility.

Safety considerations are of prime importance in operating a large-capacity scale-testing equipment. Caution should always be exercised in handling heavy test weights. Special attention is exercised to see that no one gets too close to, or under, the test weights, and to see that no one stands between them and the side of a building or other fixed object, while they are being handled by the crane. The tackle bar used for hoisting three weights at a time is arranged so that it is not necessary to touch the hooks with the hands when engaging or disengaging the weights -- this is an important safety measure, since it minimizes the possibility of injury to the fingers or hands. "Safety First" is a watchword which, perhaps needless to say, is always followed.

REQUIREMENTS FOR CORNER TESTS OF VEHICLE SCALES

Shift Test of Scales. The National Conference on Weights and Measures codified its requirements for scales in 1936. The provision relative to corner tests of vehicle scales was not modified at that time from the form adopted a number of years ago. The relevant portion of paragraph B-2w of the code was as follows:

> B-2w. Shift Test of Scales. -- A scale having four main load bearings shall give results accurate within tolerance when a load of one-quarter capacity or less is placed so that its center of gravity lies as nearly as may be over any one of the main load bearings, * * *, and when a load of one-half capacity or more is so placed at the center of any quarter of the platform, * * *.

In 1937 the National Conference added to the material quoted above, a proviso, which is quoted from National Bureau of Standards Handbook H22, the official publication containing the codes, as follows:

> Provided, however, That in the case of a vehicle scale, the tolerance to be applied to the results on the corners, shall be twice the tolerance which would otherwise be applied, but the algebraic mean of the errors on the two corners at each end of the scale shall not exceed such regular tolerance.

Factors Influencing Adoption of Amendment. Some of the factors influencing the Conference Committee on Specifications and Tolerances to recommend and the Conference to adopt the amendment were stated by the Chairman of the Committee in a letter written some time after the action, in part, substantially as follows:

> The tolerances adopted by the National Conference are intended for the use of regulatory officials of the States and cities and counties in passing upon the suitability for continued use of weighing and measuring equipment which is under their official control. There is never any objection on the part of such officials to action by a scale owner in maintaining his weighing equipment within smaller tolerances than those used by the official. The only effect of the tolerances would be to permit to remain in service, insofar as official control is concerned, certain scales which would otherwise be rejected, if and when corner errors of certain magnitudes are developed in the test.

There were made available to the National Conference Committee the results of the extensive series of tests of vehicle scales conducted by the Vehicle-Scale Testing Unit of the National Bureau of Standards during the six-month period preceding the 1937 meeting of the National Conference. A study of these data disclosed that under the original tolerance provisions, some scales would be rejected on the results of the corner tests but that these same scales gave reasonably good performance in other respects. It should be borne in mind in this connection that an individual corner of a motor-truck scale is usually not susceptible of a nose-iron adjustment; only the end can be adjusted without grinding the pivots to change lever ratios, an operation which should only be attempted in a shop. It seemed, therefore, that these scales would be unnecessarily penalized, were the original tolerances to be retained.

In the regular commercial use of a vehicle scale, it is entirely impracticable for the vehicle load to be concentrated on one corner of the platform. In practically all cases the load on any vehicle axle is reasonably well distributed between the two ends of the axle, and the relation between wheel treads and platform widths is such that each corner at either end of the scale bears approximately one-half the load at that end. It follows that if the algebraic mean of the errors on the two corners at one end of the scale is within the original tolerance, the liberalization with respect to individual corner errors will not to any material extent adversely affect the weighing performance of the scale in regular use. In this relation there may be cited the National Conference definition of a Vehicle Scale: "A vehicle scale is a large-capacity scale designed to be used to determine the weight of a motor truck or wagon, loaded or unloaded." It is probably these considerations which have influenced the very considerable sentiment which is growing up to the effect that in the routine test of a vehicle scale the corner test be discontinued and that only an end test be made, except in special circumstances.

The Committee did not wholly subscribe to the theory that is sometimes urged that improvement is gained by reducing tolerances rather than by increasing them. The Committee felt that reducing tolerances will not always result in improvement; when the tolerance is reduced to such an extent that it is very difficult or impossible of rigid enforcement, it is likely to be replaced by the judgment of the person testing, which usually results

in increasing the errors which will be allowed. Moreover, it is not infrequently the case that the testing equipment and methods employed are inadequate to develop the errors which are present in the equipment tested. The tolerances adopted by the National Conference are intended to be strictly applied as written, upon the results of an adequate test. When so applied, it is believed that the present tolerances of the National Conference for vehicle scales will not be conducive to the development of reprehensible practices in scale maintenance, and will not be found to be prejudicial to the interests of any agency concerned with commercial weighing. On the contrary, the modification of the tolerances for corner tests of vehicle scales is one of several modifications recently made, with the view of harmonizing tolerance requirements with actual conditions which exist, not for the purpose of continuing in service scales which are "inaccurate", but to the end that the tolerances may be applied in all cases with the assurance that unwarranted rejections will not be made.

Practical Effects of Amendment. Following the Conference certain questions were raised concerning the advisability of this amendment. To determine its practical effect the tests which had been made by the National Bureau of Standards with its Vehicle-Scale Testing Unit, were reviewed.

Up to January 1, 1938, 766 tests of vehicle scales had been made in 16 States and in the District of Columbia. Corner tests were made in the case of 161 of the scales tested. Of these scales only 5, or 3 percent, were found which were within tolerance after the toleranceson corner tests were liberalized, but which would not have been within tolerance before the amendment of the shift test specification, mentioned heretofore. The applicable tolerances for vehicle scales will be found on page 38 of this report.

The performance of these five scales under test by the National Bureau of Standards, is detailed on the sheets following. The results starred (*) would not be within tolerance under the requirement of paragraph B-2w before amendment. It may be said that the number of scales involved and their behavior under test amply justifies the conclusion that the amendment made by the Conference was a wise action. It is the opinion of the Bureau that the performance of each of these scales is such that it should not be condemned by the weights and measures official.

Test No. 196

TEST RESULTS

Element Under Test	Test Load		Error	
	Position	Pounds	Pounds	Percent
20,000-lb Scale. Minimum graduation - 2 1/2 lb.				
Lever system (ratio)	Left near corner	3000	0	0.00
" " "	Left far corner	3000	-3	-0.10
" " "	Left end	6000	-1	-0.02
" " "	" "	9000	-3	-0.03
" " "	Right near corner	3000	-2	-0.07
" " "	Right far corner	3000	-6	-0.20*
	(Algebraic mean of errors		-4	-0.13)
" " "	Right end	6000	-4	-0.07
" " "	" "	9000	-6	-0.07
" " "	Distributed	15000	-9	-0.06

Test No. 617

TEST RESULTS

Element Under Test	Test Load		Error	
	Position	Pounds	Pounds	Percent
10,000-lb Scale. Minimum graduation - 2 lb.				
Weighbeam	Right near corner	2000	-10	-0.50*
"	Right far corner	2000	0	0.00
	(Algebraic mean of errors		-5	-0.25)
"	Right end	3000	-5	-0.17
"	" "	5000	+1	+0.02
"	Left near corner	2000	-2	-0.10
"	Left far corner	2000	+2	+0.10
"	Left end	5000	-3	-0.06
"	Distributed	10000	+1	+0.01

Test No. 619

TEST RESULTS

Element Under Test	Test Load Position	Test Load Pounds	Error Pounds	Error Percent
8,000-lb Scale. Minimum graduation - 2 lb.				
Weighbeam	Right near corner	2000	-7	-0.35*
"	Right far corner	2000	-3	-0.15
	(Algebraic mean of errors		-5	-0.25)
"	Right end	1000	-5	-0.50
"	" "	4000	-3	-0.08
"	Left near corner	2000	0	0.00
"	Left far corner	2000	-5	-0.25
"	Left end	4000	0	0.00
"	Distributed	8000	+10	+0.12

Test No. 624

TEST RESULTS

Element Under Test	Test Load Position	Test Load Pounds	Error Pounds	Error Percent
12,000-lb Scale. Minimum graduation - 2 lb.				
Weighbeam	Left near corner	3000	+6	+0.20
"	Left far corner	3000	+2	+0.07
"	Left end	1000	-3	-0.30
"	" "	6000	+10	+0.17
"	Right near corner	3000	-10	-0.33*
"	Right far corner	3000	+2	+0.07
	(Algebraic mean of errors		-4	-0.13)
"	Right end	5000	0	0.00
"	" "	6000	+2	+0.03
"	Distributed	12000	+17	+0.14

(An automatic-indicating device was attached to this scale; the indications of this device are not included in the results given above.)

Test No.763

TEST RESULTS

Element Under Test	Test Load Position	Test Load Pounds	Error Pounds	Error Percent
25,000-lb Scale. Minimum graduation - 5 lb.				
Weighbeam	Left near corner	3000	-12	-0.40*
"	Left far corner	3000	+5	+0.17
	(Algebraic mean of errors		-3.5	-0.12)
"	Left end	9000	-15	-0.17
"	Right near corner	3000	-10	-0.33
"	Right far corner	3000	0	0.00
"	Right end	10000	-15	-0.15
"	Distributed	15000	-25	-0.17

(An automatic-indicating device was attached to this scale; the indications of this device are not included in the results given above.)

In the case of the five scales the performance of which has been detailed in the preceding, it may be said that although, as is customary with the National Bureau of Standards, the installations were carefully inspected (except in one instance, in which water was standing in the pit), no condition of faulty installation or maintenance was discovered to which the error on the corner in question could be attributed.

It has been mentioned in the preceding material that at the time the amendment was framed it was believed that as a result of the provision that the algebraic mean of the errors on the two corners at one end of the scale should not exceed the regular tolerance, the amendment would not to any material extent adversely affect the weighing performance of the scale in the course of its regular use. The review of the results of tests made by the Bureau demonstrated that, in fact, this provision was an effective safeguard, and that it was functioning as a successful deterrent to the admission to the accurate class, of scales in poor adjustment. Thus more than half of the scales inaccurate under the old tolerances on individual corners but accurate under the new, failed to comply with the proviso as to the mean error and thus failed to pass under the new shift test tolerances.

Another fact brought out was than compliance with the tolerances on corners allowable before the amendment of Paragraph B-2w by no means guaranteed the accuracy of the scale. About one-half of the scales complying with former tolerances on corner tests were found inaccurate upon the complete test of the scale. This percentage is not greatly changed by the operation of the new tolerance on corners; of the scales complying with these, 54 percent are found inaccurate at other stages of the tests. These facts again emphasize that when corner tests with a small load of test weights, 3000 pounds for instance, are relied upon by the testing agency, there will be left in service many inaccurate scales which should be condemned for repairs.

Finally it may be said that the fact that a scale is found inaccurate on shift test does not necessarily mean that it will weigh vehicle loads inaccurately, if properly used. Two scales are found which do not comply with tolerances on shift test which were nevertheless accurate at all other stages of the tests. Thus had end tests been made exclusively and corner tests wholly dispensed with, only two additional scales, or 1 percent of the total number upon which shift tests were made, would have been transferred from the "inaccurate" to the "accurate" classification.

Action Taken by Twenty-Eighth National Conference. On Tuesday, May 31, 1938, at the Twenty-Eighth National Conference on Weights and Measures, the following report was presented to the Conference by the Committee on Specifications and Tolerances:

> At the meeting of the Twenty-Seventh National Conference on Weights and Measures a certain amendment was made under the heading "Scales -- B. General Specifications, Paragraph B-2w 'Shift Test of Scales'". This amendment, in brief, increased the tolerance on a corner of a vehicle scale in use from 0.20 percent to 0.40 percent, subject, however, to the provision that the algebraic mean of the errors on the two corners at each end of the scale shall not exceed the regular tolerance applied to the end, 0.20 percent. The amendment was made after a study of the results obtained by the Bureau in its program of cooperative testing with the States, which indicated the desirability of the change.
>
> This amendment has received considerable attention since its adoption, especially at the recent meetings of the Western Railroad Scale and Weighing Conference and of the National Scale Men's Association. At the latter meeting a resolution of disagreement with the Conference action was defeated, or laid upon the table, and the National Scale Men's Association appointed a special committee to confer with your Committee on Specifications and Tolerances in relation to this matter. This special committee of the National Scale

Men's Association is composed of Messrs. H. M. Roeser, of the Streeter-Amet Company; H. H. Alfrey, of the Chicago, Rock Island & Pacific Ry. Co.; Harry Mayer, of the Chicago & Northwestern Ry. Co.; C. W. Crowley, of the Western Weighing and Inspection Bureau; and R. O. Rask; of the Alton R.R. Co. This committee sat with your Committee on Specifications and Tolerances a day or two ago and there was a free and full interchange of ideas in relation to the condition of vehicle scales in various parts of the country and especially in relation to the results which might arise in connection with the tolerance to be applied in the case of corner tests on vehicle scales. A great deal of interesting and valuable information was thus developed.

After this meeting, your Committee on Specifications and Tolerances weighed the arguments advanced by the special committee of the National Scale Men's Association. It had been strongly urged by the Special Committee that the amendment made might result in some cases in adversely affecting the character of repair work and might lower the standards of the scale repairmen. To guard against this, your Committee came to the conclusion that a further amendment to the tolerances for scales would be advisable and consequently the following proposed amendment has been incorporated in the general report of your Committee on Specifications and Tolerances, which is now available. This amendment will be considered on Friday morning when the Committee report will be brought forward for the consideration of the delegates.

"Scales -- A. GENERAL DEFINITIONS.

"Add a new paragraph to be known as Paragraph A-2q, to read as follows:

"NEW SCALES.- Scales which are about to be put into use for the first time or which have recently been put into use and are being tested for the first time by the weights and measures official. Scales which have been reconditioned or overhauled or which have been condemned for repairs by a weights and measures official and subsequently adjusted or repaired, shall, upon the first test thereafter, be construed to be 'new' scales for the purpose of the application of tolerances."

This amendment would require that to the scales in question there is to be applied the tolerance for new scales. It seems to your Committee that this is a very desirable and logical step. The tolerances on new scales are smaller -- basically one-half the value -- than the tolerances on scales in use, in

order that the new scale may remain within tolerance for a reasonable time after it is put into use, even though it may depreciate and become less accurate. It seems that scales in the class just mentioned -- reconditioned, overhauled, repaired, and adjusted scales -- might well be treated in the same manner. Specifically in relation to vehicle scales, this would reduce the basic tolerance to one-tenth of one percent on end test and distributed-load test, and to two-tenths of one percent on corner test, if such test is made. It would also suspend the special minimum tolerances on vehicle scales in use and would provide that the usual minimum tolerance on new large-capacity scales should control, namely, one-half the value of one of the minimum weighbeam graduations in the case of beam scales, and one-half the value of one of the minimum graduations on the reading face in the case of automatic-indicating scales.

(Signed) F. S. HOLBROOK, CHAIRMAN,
CHARLES M. FULLER,
JOSEPH G. ROGERS,
JOHN P. McBRIDE,
GEORGE F. AUSTIN, Jr.
Committee on Specifications and Tolerances

On Friday, June 3, 1938, the Conference defeated a motion to rescind the action of the Twenty-Seventh Conference in relation to tolerance on corner test of vehicle scales. During the debate on this proposal it was disclosed that the American Railway Engineering Association had officially recommended to the Association of American Railroads the adoption of the Conference tolerances on vehicle scales.

The Conference adopted the amendment proposed by the Committee. This amendment was a definition. However, by its terms, scales which have been reconditioned or overhauled or which have been adjusted or repaired following condemnation for repairs by the weights and measures officials are included in the category of new scales, for the purpose of the application of tolerances on the first test made after repairs; thus it is immediately apparent that tolerances on such scales are materially reduced since the values of the tolerances on new scales are, basically, one-half the values applicable to scales in use, and in the case of vehicle scales are often less than one-half these latter tolerances.

For the purposes of illustration, the effect of this amendment may be stated in terms of a specific scale as follows: Consider a 40,000-pound motor-truck scale in use having a full-capacity weighbeam graduated to 5 pounds. Consider further that this scale is being tested for the first time by a weights and measures official after it has been reconditioned or overhauled or after it has been condemned for repairs by the official and subsequently adjusted or repaired. Finally assume that the load of test weights used in the tests is 8000 pounds or more.

The tolerance in the first test on the weighbeam for an end or distributed load is 10 pounds up to and including a test-weight load of 5000 pounds and on greater test-weight loads is 2 pounds per 1000 pounds. The tolerance upon the retest for an end or distributed load is reduced to one-quarter of the minimum value stated, or 2 1/2 pounds, on test-weight loads up to and including 2500 pounds and to one-half of the above value on test-weight loads of 5000 pounds or more.

If a corner test is made the following maximum values may be allowed on a corner but only when the algebraic mean of the errors on the two corners at the end of the scale shall not exceed the tolerance on the end specified in the preceding paragraph: 20 pounds up to test-weight loads of 5000 pounds, 32 pounds on a test-weight load of 8000 pounds, and 4 pounds per 1000 pounds on test-weight loads of 10,000 pounds or more. Upon the retest of such a scale after reconditioning the tolerances on test-weight loads up to 2500 pounds are reduced from 20 pounds to 5 pounds, and the above values on larger test-weight loads are cut in half.

It will be apparent that the amendment made by the Twenty-Eighth National Conference very substantially reduces tolerance values on used scales when these scales are being tested after reconditioning or condemnation; this reduction amounts to 75 percent in some cases and to 50 percent in the usual case. It seems that expert workmanship on the part of the scale repairman will certainly be required to put a scale into such condition that it will pass the first test after repair. Thus this change should effectively forestall a situation which some have feared might arise, that the tolerance on corner test might result in lowering the standards of the scale repairman.

The fact that some time ago the American Railway Engineering Association recommended for approval by the Association of American Railroads the National Conference tolerances on vehicle scales, including the amendments made at the Twenty-Seventh Conference, is persuasive of the competency of these tolerances. The railroads of the United States have a vital interest in the subject, since they install and maintain for their use large numbers of these scales and accept weights for the purpose of the assessment of freight charges over many more of them. The care and thoroughness with which the Association investigates specifications and tolerances for scales is well known and their requirements are accorded country-wide recognition. It seems that it can not be gainsaid that a scale, whether or not it is a new or recently repaired scale, or a scale in use, will be of satisfactory accuracy when in compliance with the tolerances as now adopted by the National Conference.

STATEMENT OF VEHICLE-SCALE TOLERANCES, SR REQUIREMENTS, AND RELATED SPECIFICATION PARAGRAPHS

There are given below, for purposes of ready reference on the part of the readers of this report, (a) those paragraphs of the definitions and specifications for scales which especially affect the application of the tolerances for vehicle scales, (b) the SR (sensibility reciprocal) requirements, and (c) the tolerances for vehicle scales. This material represents the requirements adopted by the National Conference on Weights and Measures, and includes those changes adopted by the Twenty-Eighth National Conference in 1938.

A. General Definitions.

A-2q. New Scales. - Scales which are about to be put into use for the first time or which have recently been put into use and are being tested for the first time by the weights and measures official. Scales which have been reconditioned or overhauled or which have been condemned for repairs by a weights and measures official and subsequently adjusted or repaired shall, upon the first test thereafter, be construed to be "new" scales for the purpose of the application of tolerances. [1938]

B. General Specifications.

B-2w. Shift Test of Scales. - A scale having four main load bearings shall give results accurate within tolerance when a load of one-quarter capacity or less is placed so that its center of gravity lies as nearly as may be over any one of the main load bearings, * * * and when a load of one-half capacity or more is so placed at the center of any quarter of the platform * * * : Provided, however, That in the case of a vehicle scale, the tolerance to be applied to the results on the corner shall be twice the tolerance which would otherwise be applied, but the algebraic mean of the errors on the two corners at each end of the scale shall not exceed such regular tolerance.

B-2x. Increasing-And-Decreasing-Load Test of Automatic-Indicating Scales. - When tests are being made with both increasing and decreasing loads on an automatic-indicating scale, the indications on all increasing loads shall be within the regular tolerances specified, and also at any given load the range between corresponding observations for increasing and decreasing loads shall not be greater than the sum of the tolerances in excess and in deficiency for the load in question.

I. Sensibility Reciprocal (SR) Requirements.

I-1. For Large-Capacity Scales. - The maximum SR allowable on a large-capacity scale, at the capacity of the scale or at any lesser load, shall be the value of two of the minimum weighbeam graduations, except that the maximum SR allowable on a vehicle scale shall in no case be less than 10 pounds: Provided, however, That the manufacturers' maximum allowable SR,

or the maximum SR allowable on a new large-capacity scale, whether or not it is a vehicle scale, shall be the value of one of the minimum beam graduations.

J. Tolerances.

J-1. For Large-Capacity Scales.

J-1a. General. - The tolerances for large-capacity scales, in excess or deficiency, shall be the values shown * * *, except that the manufacturers' tolerances, or the tolerances for new scales, shall be one-half of the * * * values shown, * * *; and subject, in addition, to the following provisos:

1. Except as is provided herein, the tolerance on a beam scale in use shall not be less than the value of one of the minimum beam graduations; on a vehicle scale, in use, when a load of test weights of not less than 8000 pounds is employed in any test, the tolerance shall not be less than one of the following values: 5 pounds on a scale having a minimum graduation of 2 1/2 pounds or less; 10 pounds on a scale having a minimum graduation of 5 or 10 pounds; 20 pounds on a scale having a minimum graduation of 20 pounds.

2. Except as is provided herein, the tolerance on the reading face of an automatic-indicating scale in use shall not be less than the value of one of the minimum graduations on the reading face, or one five-hundredth of the capacity of the reading face, whichever is less, * * *; on an automatic-indicating vehicle scale, in use, when a load of test weights of not less than 8000 pounds is employed in any test, the tolerance on the reading face shall not be less than one of the following values: 5 pounds on a scale having a minimum reading face graduation of 2 1/2 pounds or less; 10 pounds on a scale having a minimum reading-face graduation of 5 pounds or 10 pounds; 20 pounds on a scale having a minimum reading-face graduation of 20 pounds.

3. On an automatic-indicating scale, in use, the tolerance on any beam and the tolerance on ratio shall not be less than the minimum value specified in the one or the other of the preceding provisos, whichever is less.

4. The tolerance on new scales shall in no case be less than one-half of the tolerance value arrived at by the operation of provisos 1, 2, or 3, except that the special minimum tolerance values specified therein to apply to vehicle scales only, shall not be employed in computing the values of the tolerances on new vehicle scales.

Tolerance on ratio: 1 1/2 lb per 1000 lb (0.15%). (The ratio is the multiplying power of the scale. This tolerance is applied to parts requiring the employment of removable weights.)

Tolerance on weighbeam, reading face, or unit weight indications: 2 lb per 1000 lb (0.20%).

(The tolerance is to be applied to the amount of known weight on the load-receiving element of the scale.)